International Journal of Research (IJR)

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 6
June 2021

Design, Fabrication and Control of Drone Using Arduino Microcontroller

Sanoj Kumar Karki
Department of Mechanical engineering, Chhattisgarh Swami Vivekanand Technical University, 490001 Bhilai, India

***Abstract**- Quadcopters is an aerial vehicle operated to fly independently and is one of the representation of a UAV (Unmanned Aerial Vehicle). They are controlled by pilots on the ground or simultaneously driven. They are called rotorcrafts because unlike a fixed wing aircraft, here lift is generated by a set of revolving narrow-chord aerofoils. Drones are actually very interesting and in this project we are going to study about them, their components and about its widespread applications that determine its scope for the future. They are the mixture of streams of Electronics, Mechanical and especially Aviation. Drones are of different types and have different configurations for example, bicopters, tricopters, quadcopters, hexacopters, octocopters, etc. They have different uses and accordingly different configurations are used. Hexacopters and Octocopters have better stability and yaw configuration. Control of motion of vehicle is achieved by altering the rotation rate of one or more rotors, thereby changing its torque load and thrust/lift characteristics. Quadcopters have different structures and design according to the work done by it. Components like motors, batteries and electronic speed controllers (ESC's) also vary according to the power needed and work done by quadcopter. Also the enhancements like GPS trackers or cameras or infrared cameras arc used so that they could be applied in various missions like disaster relief, search and rescue, agriculture and 3D mapping of the geography of an area. These widespread applications outshine the advantages which are rectifiable and hence this makes it a very productive technology in today's world. It is supposed to appear in full existence in the coming years. But every technology has merits as well as demerits.*

Index Terms: Unmanned Aerial Vehicle, Microcontroller, fabrication, design

Introduction

Drones are basically referred as Unmanned Air Vehicles (UAVs) that is capable of performing various tasks for human comfort. Because of its wide usage and application, Drones are gaining popularity in the recent scientific arena. Its few applications include: surveillance, rescue missions, agricultural assessment, transportation of goods, film making and many others. When four rotors are used for the purpose of propelling, it is called as Quadcopters. In Nigeria and other African regions, Drone is playing instrumental role to inspect crops, fend off pests, improve land productivity and more. In recent days, Drones arc being mobilized in military field to destroy the target and in defence purpose. Due to increasing interest, Drones are being commercially launched in the market today in various size and forms. Quadcopter or quad rotor is a special kind of Drone that consists of four rotors and is being actively applied in the field or research and development in recent years. The major technological advantage of Quadcopter over other species of its kind is its stability, simpler design and manouevrability. In helicopters tail rotor is provided to control yaw motion. Unlike helicopter, Quadcopter has four rotors where a pair of rotor move in clockwise direction and a pair rotate in anticlockwise direction. This project accentuates the prospects of drone technology through the integration of Arduino controller to navigate and locate the desired target in more convenient fashion.

PROBLEM STATEMENT

The fundamental problem of designing Quadcopter is its balancing and maintaining stability. The main factor beside the imbalance and instability of Quadcopter is wind. Thus the effect of wind has to be carefully examined. To solve this problem Integrated Development environment (IDE) is used which makes the controlling task easier.

PROJECT OBJECTIVES

The major objectives of the project are:

(a) To design Quadcopter controlled by an open source Arduino microcontroller board.
(b) To design Integrated Development Environment (IDE) to communicate and control Quadcopter.
(c) To debug the Arduino code.
(d) To test the performance of the designed Quadcopter

LITERATURE REVIEW

Breguet-Richet Gyroplane (1907): A four-rotor helicopter designed by Louis Breguet. This was the first rotary wing aircraft to lift itself off the ground, although only in tethered flight at an altitude of a few feet. In 1908 it was reported as having flown 'several times', although details are sparse.
Oehmichen No.2 (1920): Etienne Oehmichen experimented with rotorcraft designs in the 1920s. Among the six designs he tried, his helicopter No.2 had four rotors and eight propellers, all driven by a single engine. The Oehmichen No.2 used steel-tube frame, with two-bladed rotors at the ends of the four arms. The angle of these blades could be varied by warping. Five of the propellers, spinning in the horizontal plane, stabilized the machine laterally. Another propeller was mounted at the nose for steering. The remaining pair of propellers functioned as its forward propulsion. The aircraft exhibited a considerable degree of stability and increase in control-accuracy for its time, and made over a thousand test flights during the middle 1920s. By 1923 it was able to remain airborne for several minutes at a time, and on April 14, 1924 it established the first-ever FAI distance record for helicopters of 360 m (390 yd). It demonstrated the ability to complete a circular course and later, it completed the first 1 kilometre (0.62 mi) closed-circuit flight by a rotorcraft. Dr. George de Bothczat and Ivan Jerome developed this aircraft, with six-bladed rotors at the end of an X-shaped structure. Two small propellers with variable pitch were used for thrust and yaw control. The vehicle used collective pitch control. Built by the US Air Service, it made its first flight in October 1922. About 100 flights were made by the end of 1923. The highest it ever reached was about 5 in (16 ft 5 in). Although demonstrating feasibility, it was underpowered, unresponsive, mechanically
complex and susceptible to reliability problems. Pilot workload was too high duringhover to attempt lateral motion.
Convertawings Model A Quadrotor (1956): This unique helicopter was intended to be the prototype for a line of much larger civil and military quadrotor helicopters. The design featured two engines driving four rotors through a system of v belts. No tail rotor was needed and control was obtained by varying the thrust between rotors. Flown successfully many times in the mid-1950s, this helicopter proved the quadrotor design and it was also the first four-rotor helicopter to demonstrate successful forward flight. Due to a lack of orders for commercial or military versions however, the project was terminated. Convertawings proposed a Model E that would have a maximum weight of 42,000 lb (19 t) with a payload of 10,900 lb (4.9 t) over 300 miles and at up to 173 mph (278 km/h). The Hanson Elastic Articulated (EA) bearingless rotor grew out of work done in the early 1960s at Lockheed California by Thomas F. Hanson, who had previously worked at Convertawings on the quadrotor's rotor design and control system.
Curtiss-Wright VZ-7 (1958): The Curtiss-Wright VZ-7 was a VTOL aircraft designed by the Curtiss-Wright company for the US Army. The VZ-7 was controlled by changing the thrust of each of the four propellers.
Current Development

In the last few decades, small-scale unmanned aerial vehicles have been used for many applications. The need for aircraft with greater maneuverability and hovering ability has led to a rise in quadcopter research. The four-rotor design allows quadcopters to be relatively simple in design yet highly reliable and maneuverable. Research is continuing to increase the abilities of quadcopters by making advances in multi-craft communication, environment exploration, and maneuverability. If these developing qualities can be combined, quadcopters would be capable of advanced autonomous missions that arc currently not possible with other vehicles.

Some current programs include:

The Bell Boeing Quad Tilt Rotor concept takes the Fixed quadcopter concept further by combining it with the tilt rotor concept for a proposed C-130 sired military transport.

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 6
June 2021

Flying prototype of the Parrot AR.Drone

AeroQuad and ArduCopter arc open-source hardware and software projects based on Arduino for the DIY construction of quadcopters.
Parrot AR.Drone is a small radio controlled quadcopter with cameras attached to it built by Parrot SA, designed to be controllable by smartphones or tablet devices.

Nixie is a small camera-equipped drone that can be worn as a wrist band. Several camera-drone projects have turned into high-profile commercial failures:

Zano (drone) - a high-profile Kickstarter project to build a quadcopter-camera drone, Zano failed after delivering only a small fraction of their orders in a partially nonfunctional state.

Lily Camera - a startup attempting to make a quadcoptcr-camcra drone, sued by the San Francisco District Attorney after they closed down without fulfilling any of their pre-orders.

SUMMARY OF PROJECTS AND COMPONENTS

Introduction

Our project is basically divided into three main components viz. Design, Fabrication and Control. We used Arduino UNO microcontroller board to inspect the system states through various sensors. We initially built a model and were able to ascend the Drone to a substantial height using 90% of the total PWM. The rest of the motor force is used in stabilizing and control of the Quadcopter. We faced different challenges during the initial testing of Drone. Due to the coding error, Drone got initially crashed. The different sensors and components used in our Quadcopter platform were explored and evaluated, which has been briefly discussed below.

Frame

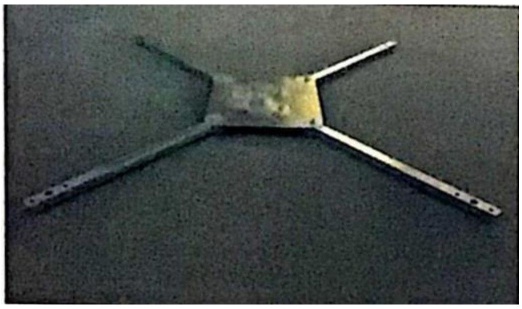
The Frame of our quadcopter have enough strength and flexibility that compensates the vibrations the motors produce. The frame of our Quadcopter have the following parts:

Copyright © authors 2021

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 6
June 2021

Center Holding Plate — For mounting the electronics Arms

Motor Brackets The frame can be made of aluminium, carbon fiber or wood but the material that is mostly used for the arms is aluminium. More precisely, the square hollow rails are made of aluminium. They arc relatively lightweight, rigid and cheap. But, since they are not known as great compensators for the motor vibrations like carbon fiber ones are, they can confuse the sensors.



Arduino UNO Board:

During our project we used Arduino UNO which was sufficient for our project. During the development of our project we found that Arduino Uno had few advantages over other boards. Its ready to use structure made us really easy to use and operate. There are many functions present in the software of Arduino which makes coding so easy and fast that is not possible with simple microcontroller. The basic specification of Arduino UNO is given below:

Microcontroller	ATmega328p
Operating voltage	5V
Input voltage	7-12V
Digital I/O Pins	14
Flash Memory	32 KB (ATmega328p)
SRAM	2 KB (ATmega328p)
Length	68.6mm
Width	53.4mm

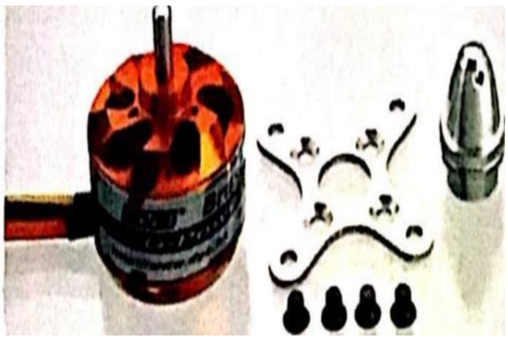
Specifications of Arduino UNO

Copyright © authors 2021

The programming language used in Arduino is Java, with a huge number of official libraries that can be used in the code.

Motors

Our project used high quality reliable motors with quick response to control the quadcopter. If there happens to be any problem with the motors, this can cause devastating problem not only to the quadcopter but also to the people and property. Furthermore, motors are to be powerful to lift the Quadcoptcr to a substantial height and should perform various aerial movements. The motors used should respond quickly to give a stable flight to the Quadcopter.



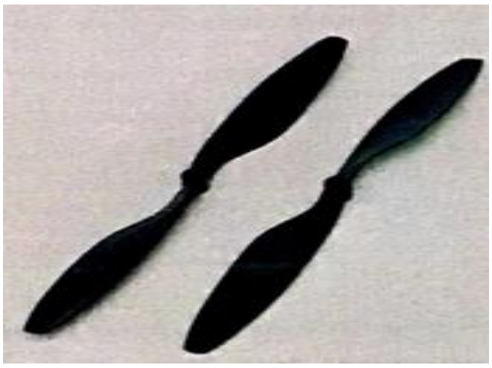
Brushless Motors

We used 1400 KV DYS G-Power series Brushless Motors. This motor was sufficient for our project and we could perform quick movements if necessary.

Propellers

A propeller is a type of fan that transmits power by converting rotational motion into thrust. A pressure difference is produced between the forward and rear surfaces of the air foil-shaped blade, and a fluid (such as air or water) is accelerated behind the blade. Propeller dynamics can be modelled by both Bernoulli's principle and Newton's third law. A marine propeller is sometimes colloquially known as pitch of the screw. Generally, increased propeller pitch and length will draw more current. Also the pitch can be defined as the travel distance of one single prop rotation. In a nutshell, higher pitch means slower rotation, but will increase your vehicle speed which also use more power. In our project we required a pair of clockwise (CW) and anticlockwise (ACW) propellers. We used 1045/1045R Oem Propeller which is shown in the figure below. The total length of the propeller is 10 inch and the slope is 4.5 inch. It weighs 41 grams.

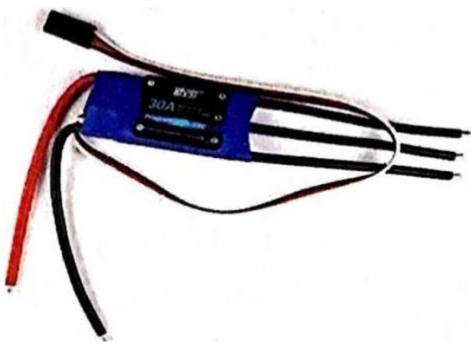
Copyright © authors 2021



Propeller used in our Quadcopter

Electronic Speed Controller

The purpose of the Electronic Speed Controller (ESC) is to vary an electric motor's speed. ESCs used most be fast and reliable so that rapid response of motors be realized. We used the dys series 3M ESC developed by Robo India. it produces 3 separate waves (one for each wire to the motor). The speed of the motor has nothing to do with voltage or amps, but instead the timing of the current fed into it. By increasing and decreasing the wave length (frequency) of the trapezoidal wave on the 3 phases, the ESC causes the motor to spin faster and slower. The ESC switches the polarity of the phases to create the waves. This means that the voltage through any given winding flows 'Alternately' one direction then the other.



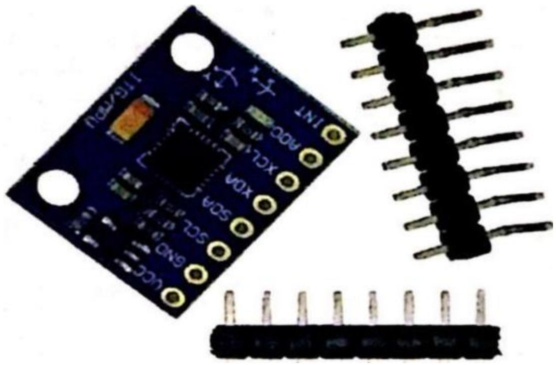
Operating Current	30A
Weight	222 grams
BEC	5V/2 Amp
Material	Lithium-Polymer

Gyroscopic Sensor-

Gyro sensors, also known as angular rate sensors or angular velocity sensors, arc devices that sense angular velocity. In our project we used GY-521 MPU6050 Gyro-sensor Module that contained three accelerometers

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 6
June 2021

for Arduino. An accelerometer is an electromechanical device used to measure acceleration forces. Such forces may be static, like the continuous force of gravity or, as is the case with many mobile devices, dynamic to sense movement or vibrations. Acceleration is the measurement of the change in velocity, or speed divided by time. The sensor used in our project is shown in the figure below:

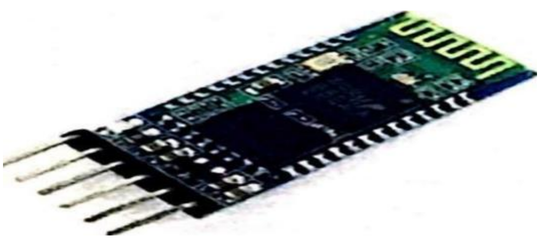


The specification of the Gyro-sensor Module is given in the table below:

Brand Name	REES52
Voltage	5 volts
Series-number	GY-521
Width	2.11 cm
Length	3cm
Weight	18gm

Bluetooth Module-

Bluetooth is a wireless technology standard for exchanging data over short distances (using short-wavelength Ul IF radio waves in the ISM band from 2.4 to 2.485 GIlz) from fixed and mobile devices, and building personal area networks (PANs). Range is approximately 10 Meters (30 feet). We decided to use I IC-05 Bluetooth Transceiver. Module with TTL outputs are used in this project.



Copyright © authors 2021

The basic specifications of the Bluetooth module used are-

Brand name	REES52
Colour	Green
Material composition	Silicon
Weight	9 grams
Frequency	2.4 GHz ISM Band

Drone

The Drone is basically powered by using battery pack. Battery has to operate within the limits of microcontroller, and battery must provide power to sustain the flight to at least 10-15 minutes. We decided to choose battery of 2200 mAh 3S 35C LiPo manufactured by SunRobotics.

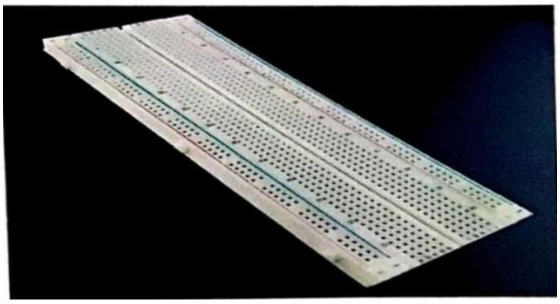
Material composition	Lithium-polymer
Numner of cells	3
Voltage	11.1
Connector plug	XT60 Connector

Breadboard:

A breadboard is a construction base for prototyping of electronics. Originally it was literally a breadboard, a polished piece of wood used for slicing bread. In the 1970s the solderless breadboard (AKA plugboard, a

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 6
June 2021

terminal array board) became available and nowadays the term "breadboard" is commonly used to refer to these.



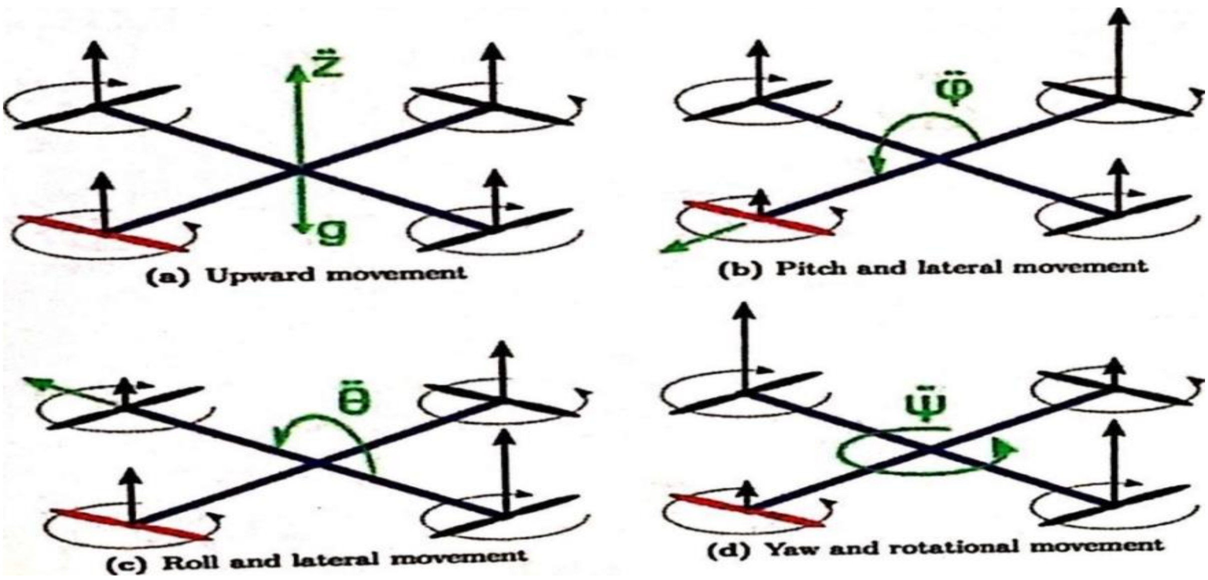
METHODOLOGY

This chapter is divided into two phases. The first phase is understanding the structure of the Quadcopter and its basic mathematical modelling. The last phase deals with the design and construction of the Quadcopter. It will be built by splitting the design into different component whereby each component will be tested to ensure its working properly. The major objective is to minimize the risk of accidents that may lead to increase in component cost.

Motion of Quadcopter:

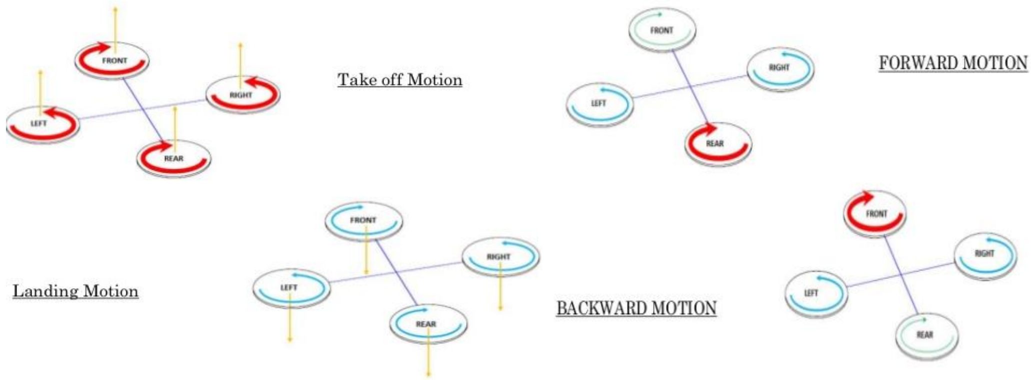
Quadcopter is a small device with four propellers attached to rotor located at the cross frame. This aim for fixed pitch rotors are used to control the vehicle motion. The speed of these rotors are independent. By independent, pitch, roll and yaw motion the aerial movement of the vehicle can be controlled easily. Pitch, roll, yaw and altitude movement of the quadcopter is shown in the figure:

Take-off and landing motion-



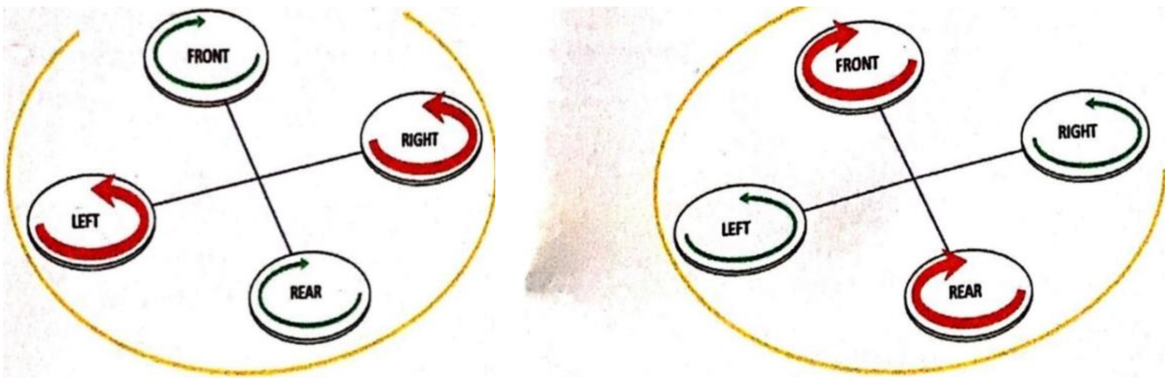
Take off motion is controlled by changing the vertical position.

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 6
June 2021



Left and right motion

The left and right motion of the Quadcopter can be controlled by varying the yaw angle of Quadcopter. Yaw angle can be controlled by increasing (decreasing) counter¬clockwise rotors speed while decreasing (increasing) clockwise rotor speed. The left and right motion is shown in figure below:



Right Motion

Hovering or Static motion:- The hovering or static Position of Quadcopter is done by two pairs of rotors rotating in clockwise and anticlockwise direction. The total sum of the reaction torque becomes zero and this allows Quadcopter to remain in the hover position.

RESULTS AND DISCUSSIONS

This section of the project deals with the verification and testing of each hardware and software component. All problems encountered will be described in detail and the solutions of the problems is also addressed. We on this section will also discuss about the overall results of the project and the steps we could have taken to improve our project. Future work on this topic will also be discussed in this section of the document. In this section of the report, we will discuss the methods we used to test each component of our quadcopter, the problems we faced and how we solved them.

Verifying sensors board and Arduino UNO connection –

By using the blinking template from the Arduino IDE and looking at the corresponding LED on the Arduino board and shield, we verified that both the boards were connected properly by changing the delay of the blinking LED.

Testing on Aeroquad flight software library-

Copyright © authors 2021

To modify the Aeroquad flight software, the user configuration header file had to be changed. Certain variables needed to be defined according what components our quadcopters had and what functions we wanted our quadcopter to perform. This was done by both commenting and uncommenting the necessary definition statements in the user configuration header file. If the software uploads successfully, then no mistakes were made in the user configuration header file.

Drone is getting popular as it has wide range of applications, ranging from agricultural, photography, journalism, geological survey, and many other fields. Developments and modifications are constantly being done on the structure and internal electronics. The new "helicopter drone" released by the US army carries a 1.8 giga pixel camera to provide clear ground images even from high altitudes. The sensor carries in the drones are also being made sharper to provide higher aerial surveillance. Programming software of the drone is being developed such that the drone can take its own decision in situation where human error is possible. Drones have always risen to the occasion whenever they were needed. They are truly and engineering spectacle, containing the best of electronics, mechanical and software technology.

Use of Drones:

Drones today have found various applications in wide areas. Some of the applications of Drones arc discussed below:
-Surveying/Mapping/GIS
-Inspection
-Science and research
-Monitoring and surveillance
-Search and rescue
-Unmanned cargo
-Aerial video and photography

CONCLUSIONS-

Throughout this paper, we developed a quadcopter sensor platform from scratch, including system modelling, state estimation, control design, communication handling and implementation of a user interface. The quadcopter was successfully built as per the initial objectives. The quadcopter can fly upto a height of 1511 with the load that is presently being used in the system. The complete weight of the system, including the weights of the components, adds upto 1.5 Kg. The RC transceiver used has a maximum range of I mile with LOS communication. This can be now used to deliver lightweight payloads. The collision detection feature has been with the short range of IR sensors that is being used. We have used the battery indicator that beeps in case of low voltage. This is sensed by a microphone interfaced to the arduino and the system is landed safely before the charge discharges completely. The initial goal of creating an autonomous quadcopter capable of sensing obstacles was achieved. The complete project needs knowledge from various field like robot design, fabrication, control and mainly Arduino programming. Important soldering and electric fabrication techniques including making a power harness is required at various stages of the project. Arduino programming, particularly the stabilization was the most complex part of the project which was achieved because of the efforts by the complete group. We succeeded in stabilizing the quadcopter in six degrees of freedom. This project has given us valuable experience when it comes to; system modelling, advanced filtering and estimation methods, control algorithms, graphical user interface development, project management, microcontroller programming and conduction of an extensive project. We arc satisfied with our overall achievements and everything we have learned through the execution of this project.

Recommendation for further development-

-Other kinds of signal transmission devices can be used such as GSM module which provides a longer range of control.
-GPS module can be added and the Quadcoptcr can be programmed to reach specific coordinates autonomously.
-Camera can be integrated to the system for video surveillance.
-A setup to carry lightweight payloads can be implemented

p-ISSN: 2348-6848
e-ISSN: 2348-795X
Vol. 8 Issue 6
June 2021

-Robust stabilization has to be achieved to overcome glitches (loss of control during flight).
A longer flight time is a trade-off between two variables, the efficiency of the thrust developed by motors and the battery capacity. A means to reduce the system weight has to be found.

REFERENCES

(MANITOBA University, Final Report Design, Implementations, and Testing of a UAV Quadcopter DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING.

Warren R. (1982). The Helicopters. The Epic of Flight (Chicago: Time-Life Books) p. 28. ISBN 0-8094-3350-8
"A successful French Helicopter" Flight 24 January 1924 p47
"Helicopters of the World" Flight 2 November 1956 p722
"The Quadrotor's coming of age". Retrieved 29 December 2014.

University of MANITOBA Final Report Testing of UAV.

Wikipedia (en.wikipedia.org/wiki/Quadcopter)

The Future of Drones- Wikistrat Report (http://www.wikistrat.com/the-future¬of-drones-summary-report!)

Allison Ryan and J. Karl Hedrick (2005). "A mode-switching path planner for UAV- assisted search and rescue." 44 IEEE Conference on Decision and Control, and the European Control Conference 2005.

Atheer L. Salih, M. Moghavvemil, Haider A. F. Mohamed and Khalaf Sallom Gaeid (2010). "Flight PID controller design for a UAV Quadcopter." Scientific Research and Essays Vol. 5(23), pp. 3660-3667, 2010.

A. Zul Azfar and D. Hazry (2011). "Simple GUI Design for Monitoring
of a Remotely Operated Quadcopter Unmanned Aerial Vehicle." 2011 IEEE

International Colloquium on Signal Processing and its Applications.

Kong Wai Weng (2011). "Quadcopter " Robot Head To Toe Magazine
September 2011 Volume 3, pp. 1-3.

Duckgce Park, Moon-Soo Park, Suk-Kyo Hong (2001). "A Study on the 3-DOF Attitude Control of Free-Flying Vehicle." ISIE 2001,Pusan,KOREA

Ashfaq Ahmad Mian, Wang Daobo (2007). "Nonlinear Flight Control Strategy for an Underactuated Quadrotor Aerial Robot" 2007 IEEE Journal 15.Markus Achtclik, Tianguang Zhang, Kolja Kuhnlcnz and Martin Buss (2009).

"Visual Tracking and Control of a Quadcopter Using a Stereo Camera System and Inertial Sensors." Proceedings of the 2009 IEEE Conference on Mechatronics and Automation.

Matilde Santos, Victoria Lopez, Francisco Morata (2010). "Intelligent Fuzzy Controller of a Quadrotor" 2010 IEEE Journal.

Copyright © authors 2021